Harris, J. Donald

USE OF AUDITORY CUES BY THE BLIND FOR TRAVEL.


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BY THE BLIND

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Edited

by

J. Donald Harris

Interim Progress Report
Contract No. RD-510
1 July 1961

For

Research Concerning Identifying and Teaching
Auditory Cues for Traveling in the Blind

To

Department of Health, Education, and Welfare
Office of Vocational Rehabilitation
Washington 25, D. C.
and
Seeing Eye, Inc.
Morristown, New Jersey

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ABSTRACT

This report reviews work done in the first fourteen months and covers progress in the last six months' period on the following:

a) The mobility competency scale was validated on both sighted and non-sighted subjects.

b) Interview material was prepared and supplementary tests (intelligence and emotional factors) were chosen.

c) The primary auditory abilities test was completed and testing of subjects begun.

d) A training tape containing binaural recording (stationary and moving) with commentary was completed.

e) The paradigm design for studying the effects on actual mobility of training materials (tactile map and binaural training tape) was chosen and all twenty-eight subjects called for were completed but not analyzed by 1 August 1961.

f) A theoretical model was developed for the interaction of subjects, objects and sounds.

STAFF

DIRECTOR OF RESEARCH: J. D. Harris, Ph.D.

RESEARCH ASSOCIATE: H. N. Wright, Ph.D.

ADMINISTRATIVE ASSISTANT: D. Winer, A.M.

RESEARCH AUDIOLOGIST: J. F. Curtis, Ph.D.

CONSULTANT: J. K. Dupress

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I INTRODUCTION

J. K. Dupress

The principal goals of this project are:

1) To study differences between the capabilities of good and poor travelers with particular reference to auditory task performance.

2) To provide tests which measure individual differences in mobility capability which can then be used in rehabilitation centers.

3) To develop training tapes which can be incorporated into existing mobility training programs.

Considerable progress has been made in the past six months covered by this report toward each of these goals. A fairly complete interview and test battery have been prepared.

As this report is being written, testing has begun and duplicates of the training tape have been forwarded to other organizations.

II MOBILITY SCALE

H. N. Wright

Mobile blind individuals frequently are classified both by themselves and rehabilitation counselors as "good travelers" or "poor travelers". Those who travel only in their home and its surroundings are classified as "home-bound". Although such descriptions are useful in some circumstances, they are too vague to permit a well-defined classification of mobility competency. The purpose of this investigation was to develop a mobility scale so that blind travelers could be systematically classified on an ordered scale.

Requirements.

Two requirements for the mobility scale were: (1) it should be applicable to all blind, and (2) it should be based on what the blind individual does, not on his intent. The type of scale developed within these two requirements is ordinal. No assumption is made about the distance between the values on the scale.*

Assumptions.

The mobility scale designed to meet the requirements set forth above rests on four assumptions. Each assumption describes scale relations which, when combined, permit the construction of the mobility scale.

Assumption 1: Traveling indicates a greater degree of mobility competency than not traveling.

Those blind individuals who restrict their traveling to their own home are not considered mobile. By traveling we simply mean going from one place to another, usually with a purpose.

Assumption 2: Traveling in unfamiliar environments indicates a greater degree of mobility competency than traveling in familiar environments.

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*See W. S. Torgerson, "Theory and Methods of Scaling" (John Wiley & Sons, 1958) for a recent discussion of scaling procedures.

The criterion for familiarity is based, in part, on predictability. By a familiar environment is meant an area in which only the minor aspects change; a certain degree of uncertainty is introduced over which the traveler has no control. For example, the route from a blind traveler's house to a nearby store might be classified as a familiar environment. An unfamiliar environment is one in which the traveler has never been.

Assumption 3: Travel competency can be ordered on a dimension of dependency. Such a scale from no dependency to complete dependency is:

1. none
2. cane
3. guide dog
4. companion

The above four-point scale includes the most common modes of assistance used by blind travelers. The amount of assistance used by a blind individual, however, may be determined by the type of environment in which he is traveling.

Assumption 4: A blind person will not travel with less assistance in an unfamiliar environment than in a familiar environment.

This assumption applies to those blind individuals who travel; and is related to assumptions 2 and 3. Ten combinations that relate the amount of assistance to each kind of environment are shown in figure II-1. The connecting lines represent all the possible combinations under this assumption.

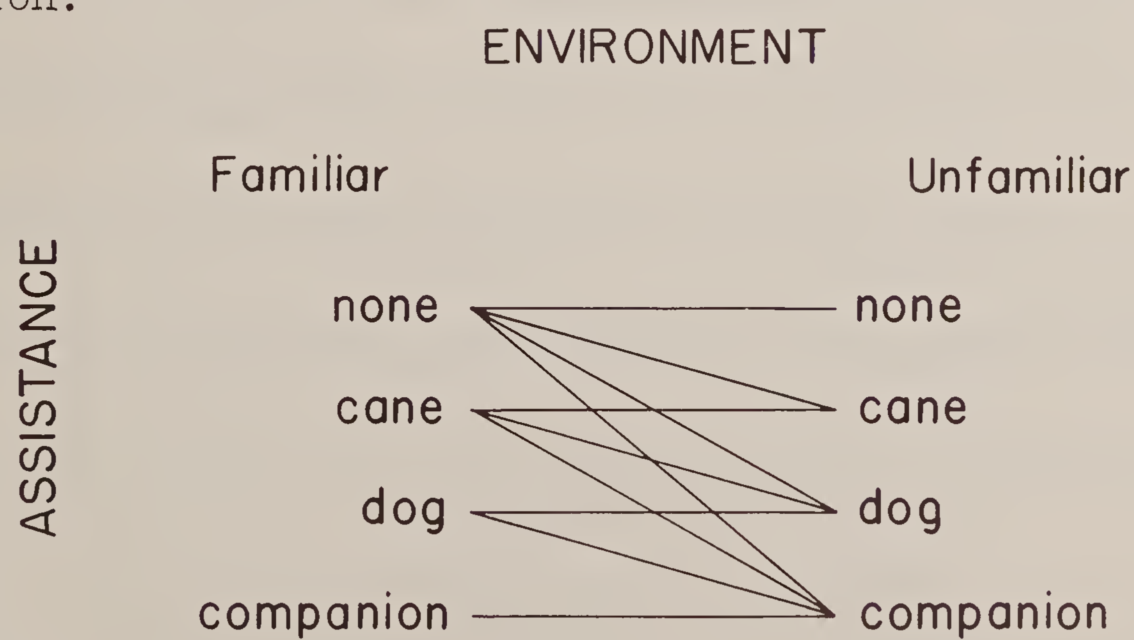

Figure II-1. The relation between amount of assistance and kind of environment under assumption 4.

Mobility Scale

1. travels in familiar environments with no assistance
   travels in unfamiliar environments with no assistance

2. travels in familiar environments with no assistance
   travels in unfamiliar environments with a cane

3. travels in familiar environments with no assistance
   travels in unfamiliar environments with a guide dog

4. travels in familiar environments with no assistance
   travels in unfamiliar environments with companion

5. travels in familiar environments with a cane
   travels in unfamiliar environments with a cane

6. travels in familiar environments with a cane
   travels in unfamiliar environments with a guide dog

7. travels in familiar environments with a cane
   travels in unfamiliar environments with a companion

8. travels in familiar environments with a guide dog
   travels in unfamiliar environments with a guide dog

9. travels in familiar environments with a guide dog
   travels in unfamiliar environments with a companion

10. travels in familiar environments with a companion
    travels in unfamiliar environments with a companion

11. travels in familiar environments with no assistance
    does not travel in unfamiliar environments

12. travels in familiar environments with a cane
    does not travel in unfamiliar environments

13. travels in familiar environments with a guide dog
    does not travel in unfamiliar environments

14. travels in familiar environments with a companion
    does not travel in unfamiliar environments

15. does not travel in familiar environments
    does not travel in unfamiliar environments

Results.

The 15-point mobility scale was constructed from the foregoing assumptions. Successive degrees of mobility are ordered from the greatest degree to the least degree of mobility competency.

Validation.

Although the assumptions used to obtain the mobility scale are reasonable, their combined use might introduce some systematic effects which could disrupt the relative position of some scale values. Validation of the scale was accomplished by a paired comparisons technique.

Procedure: The description of each scale position was paired twice with all others, the second time opposite in order to the first. Such pairing of the fifteen scale positions yielded 210 pairs. These pairs were presented singly to five judges in a different random order to each. The judges were asked which of the two scale descriptions they received represented, in their opinion, the greatest degree of mobility competency. The results from these comparisons were then correlated with the mobility scale from which the original pairs were drawn. High and significant correlations between the judges' ratings and the logically derived scale indicate that the mobility scale as defined previously is valid.

Five judges were used in this validation. Two judges were blind travelers; one used a cane, and the second used a guide dog. Of the three sighted judges; the first was associated with research on problems of the blind, the second was a counsellor in a rehabilitation center for the blind, and the third had no association with the blind whatsoever.

Results: The scale positions for each judge are shown in Table 1. All the correlations are significant at less than the .01 level of confidence. The average rank order correlation coefficient for all judges was .91, and means that the scale previously derived is a valid indication of mobility competency.

Table 1: Rank order and correlation of each judge with the scale of mobility competency.

Basic Scale Rank	Blind: cane	Blind: dog	Sighted: counsellor	Sighted: research	Sighted: naive
1	8.5	4.5	10.0	1.0	1.0
2	1.0	1.5	1.0	2.0	2.0
3	2.0	1.5	3.0	3.0	3.0
4	5.0	7.0	8.5	6.0	4.0
5	3.0	3.0	2.0	4.0	5.0
6	4.0	4.5	4.0	5.0	6.0
7	6.5	9.0	5.5	7.0	7.5
8	6.5	6.0	5.5	8.0	7.5
9	8.5	8.0	7.0	9.0	9.0
10	10.0	11.5	8.5	10.0	10.0
11	11.0	11.5	12.5	11.0	11.0
12	12.0	11.5	11.0	12.0	12.0
13	13.0	11.5	12.5	13.0	13.0
14	14.0	14.0	14.0	14.0	14.0
15	15.0	15.0	15.0	15.0	15.0
rho	.875	.921	.762	.989	.999

(Columns: Scale Position Derived from each Judge's Ratings)

Summary.

A 15-point scale of mobility competency was developed so that blind individuals could be systematically evaluated on their degree of travel skill for both research and clinical purposes. This scale was found to be a valid indication of the degree of mobility competency by a representative panel of five judges.

Continuation.

There are no plans within this project to continue this aspect further. Our only interest in developing the scale of mobility competency was to define the degree of travel skill of those blind individuals who will participate in this investigation.

III INTERVIEW

D. Winer

Each subject was given an interview consisting of a questionnaire and supplementary tests. The information from this interview was used to describe the sample of blind subjects in this investigation as well as to relate mobility competency to I.Q. and emotional stability.

Questionnaire.

The questionnaire was divided into three categories: general descriptive data, travel training, and mobility competency.

General Descriptive Data (Questions 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 18, 19): These questions provided statistical information about the sample. They required no value judgements from either the examiner or the subject; and had to do with such items as name, date, place of birth, etc.

Travel Training (Question 15): The questions in this category were designed to furnish information about travel training programs (formal or informal) in which the subject may have participated. Each subject was also asked if he thought the program was helpful.

Mobility Competency (Question 17): The purpose of this division was to determine the subject's position on the 15-point mobility competency scale developed for this investigation. The subject's mobility competency was determined by relating the type of assistance (none, cane, dog, companion) used in both familiar and unfamiliar environments. An unfamiliar environment was one in which the subject never traveled. A familiar environment was one in which the subject previously traveled. If the subject's travel was restricted to his home and yard, he was classified as homebound.

Supplementary Tests.

Each subject was given the Verbal Scale of the Wechsler Adult Intelligence Scale (WAIS 1955) and the Emotional Factors Inventory (EFI).

WAIS: The purpose of this test was to determine each subject's I.Q. The hypothesis was that mobility competency and I.Q. are positively correlated.

The WAIS consists of Verbal and Performance Scales. The latter was not applicable to this investigation because sight is required for this portion of the test. Each subject was given the verbal scale composed of the following six tests: (1) Information, (2) Comprehension, (3) Arithmetic, (4) Similarities, (5) Digit Span, and (6) Vocabulary.

EFI:* The purpose of this test was to obtain an estimate of each subject's emotional stability so that it could be correlated with his mobility competency; the hypothesis was that emotional stability, as indicated by the EFI, is highly correlated with mobility competency.

The EFI is a personality inventory which includes material indicative of personality characteristics as well as material indicative of problems arising from blindness. Each subject was given the complete inventory, composed of the following eight (8) categories: Sensitivity, Somatic Symptoms, Social Competency, Attitudes toward Blindness, Feelings of Inadequacy, Depression, Paranoid Tendencies, and Validity.

Preliminary Results.

Only two totally blind subjects were available for testing; consequently neither hypothesis could be adequately tested. Until more data are collected it is impossible to formulate any conclusions at all.

Continuation.

It is proposed that in the near future the questionnaire and supplementary tests be administered to 25 totally blind subjects. These subjects will be obtained through agencies for the blind in the New York City area.

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* Mary K. Bauman, A Comparative Study of Personality Factors in Blind, Other Handicapped, and Non-Handicapped Individuals. U. S. Office of Vocational Rehabilitation, Rehabilitation Service Series, No. 134. Washington, D.C., (1950)

Mary K. Bauman, Emotional Factors Inventory. Philadelphia (1604 Spruce St.), Privately distributed, n. d., Mimeo.

IV USE OF AUDITORY INFORMATION

H. N. Wright

The following experiments are designed to test the hypothesis that differences in mobility among blind travelers is related to their ability to use auditory information. If good travelers perform better than poor travelers, then the inference is that one reason for differences in mobility among the blind is the differences in their ability to use auditory information. Three different kinds of experiments are being conducted: (1) head-position identification, (2) street-crossing decisions, and (3) primary auditory abilities.

Head-Position Identification.

One task the blind face throughout the day is the determination of the location of a sound source. Recordings were made (with an Ampex 300, 2 channel tape recorder) from a dummy head in which separate microphones (WE 640 AA) were placed flush with the head at each ear. A playback of recordings through earphones (Beyer) simulated the original field listening conditions later in the laboratory.

Procedure: The dummy head was placed by a highway and 15-minute recordings at 15 ips were made as the head faced: (1) 90° left, against the traffic; (2) 90° right, with the traffic; (3) straight ahead, left ear against and right ear with the traffic; (4) 45° left, between 90° left and straight ahead; and (5) 45° right, between 90° right and straight ahead. Homogeneity among the recordings of the five positions was obtained by selecting a 20-second sample from each such that no one sample had a unique pattern (such as the sound from some foreign cars) and each had a continuous traffic flow.

A $7\frac{1}{2}$ ips test tape was prepared by dubbing 50 test items, 10 for each position, from the 20 second samples. The order of appearance of each item (position recording) was random with the restriction that no one item followed itself. So that none of the test items could be identified by their beginning and ending characteristics, selection of 15 second test segments from the 20 second samples was fortuitous. Specifically, 15-second lengths of recording tape were separated by 5-second lengths of non-recording leader and timing tape. The 20-second samples were also separated by leader and timing tape. The 15-second test items were dubbed by first starting a 20-second sample on one tape recorder and then starting a second tape recorder such that the 15-second test segment was recorded from some portion of the original 20-second sample.

Four subjects listened alternately to the recordings and to the traffic where the original recordings were made and adjusted the playback level to equal that of the traffic. The mean level adjusted by all subjects relative to an arbitrary 1000-cps calibration tone on each channel was the level used to present the test items to each subject.

The task for each subject was to identify the position of the head during the original recordings. He was told that any one 15-second test item was as likely as any other, and would be followed by the next in five seconds. In addition to identifying the position of the head during the original recordings as (1) left 90°, (2) left 45°, (3) front 0°, (4) right 45°, and (5) right 90°, he indicated whether he thought his response was correct or incorrect by saying yes or no after each identification response. The purpose of the additional yes-no response is discussed in the following section on analysis.

To familiarize the subjects with the task and answer questions, 15 practice items were presented before the 50 test items. The subjects were not told these items were included, nor were they told about the adequacy of their responses. After 65 items (15 practice, 50 test) were presented, the subjects were given a 5 to 15 minute rest. They were then tested again, beginning somewhere between the fifth and tenth practice item, with the earphones reversed.

The responses to the practice items were not used in the analysis of the results. The responses obtained during normal and reversed earphone placement were pooled to give a total of 100 items (20 for each position) for this test of head position identification.

Analysis: Two different kinds of data were obtained from this experiment: (1) the ability to correctly identify the head positions; (2) the subject's criterion.

The ability of subjects to correctly identify the head positions may be analyzed in two ways. The most obvious is percent correct. The second and perhaps more useful way is information transmitted (in bits/response). Such an analysis, unlike percent correct, is sensitive to the distribution of errors and recognizes approximations to correct responses. A description of how this analysis was applied to word identification task may be found in a technical report by Egan*.

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*James P. Egan, Message Repetition, Operating Characteristics, and Confusion Matrices in Speech Communication. ASTIA Document No. AD 110,064 (1957)

The purpose of the yes-no after each subject's response was to determine the criterion he used while identifying the head positions. Since a subject said either yes or no and was either correct or incorrect in identifying a particular item, his behavior is described by four possibilities. These are (1) saying yes when he was correct, (2) saying yes when he was incorrect, (3) saying no when he was incorrect, and (4) saying no when he was correct. These four alternatives are actually the following four respective conditional probabilities:

P(Y|C)	Correct Conformation
P(Y|I)	Incorrect Conformation
P(N|I)	Correct Rejection
P(N|C)	Incorrect Rejection

Y = Yes
N = No

C = Correct Identification
I = Incorrect Identification

This type of analysis to describe a listener's behavior is not old. The first of a series of tutorial papers on this subject has recently appeared.* The following group of experiments on head-position identification is in many ways analogous to previous experiments by Clark on word identification.**

Of the four conditional probabilities, only two are needed to specify the criterion of a listener. These are his correct and incorrect conformations. If a listener adopts a strict criterion, both his probability of correct conformation and incorrect conformation will be low because, generally speaking, he will confirm only those responses he is sure of. If a listener is lax, however, he will confirm so many responses that both the probability of his correct and incorrect conformations will be high. The criterion varies on a continuum from very lax to very strict and can be specified exactly.

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*David M. Green, Psychoacoustics and Detection Theory. Journal of the Acoustical Society of America, 32, 1189-1203 (1960)

**Frank R. Clark, Constant Ratio Rule for Confusion Matrices in Speech Communication. Journal of the Acoustical Society of America, 29, 715-720 (1957)

Frank R. Clark, Confidence Ratings, Second-Choice Responses, and Confusion Matrices of Intelligibility Tests. Journal of the Acoustical Society of America, 32, 35-46 (1960)

Hypotheses: In addition to testing the hypothesis that good travelers are better able to identify the head positions than poor travelers, this experimental task defines each subject's criterion. The hypothesis is that blind travelers high on the mobility scale are lax; and that those low on the scale are strict. Heuristically such a hypothesis is reasonable because the blind who travel with little assistance frequently make errors that do not seem to restrict their activity. If they do not accept these errors, they would probably require more assistance and consequently be low on the mobility scale.

Experiment I: The ability of five sighted normal hearing subjects to identify the head positions was determined under four criteria which varied from strict to lax. The performance and criteria of each subject were analyzed and compared.

Figures IV-1 and IV-2 summarize the results over successive test administrations. From this analysis we see that no substantial change in either percent correct or information transmitted occurred over successive trials. An analysis of variance (Friedman) of these results was not significant at the .50 level of confidence.

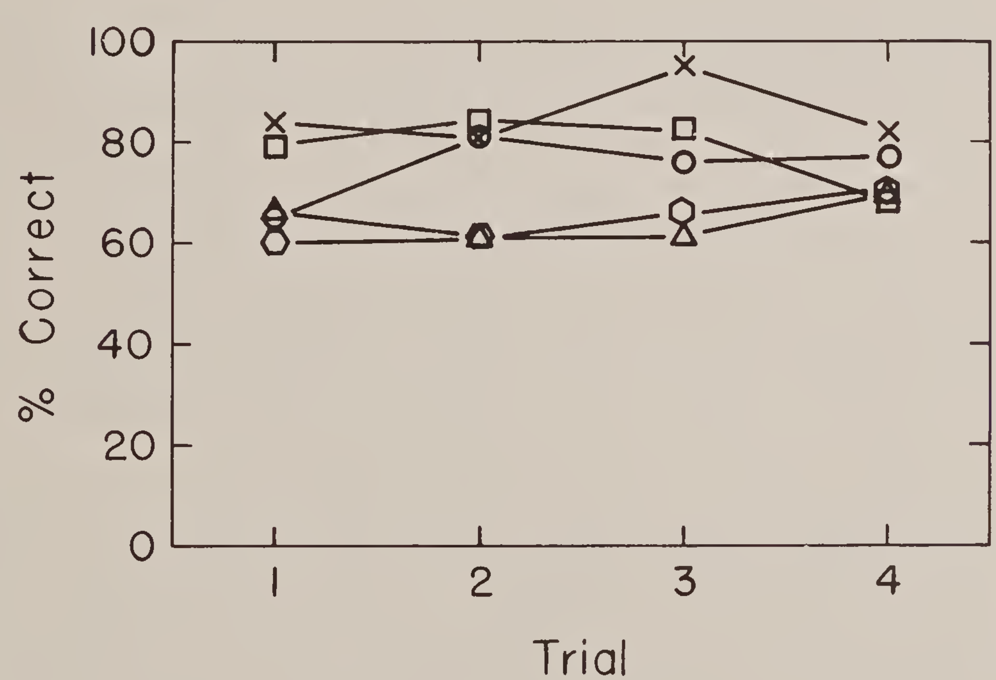

Figure IV-1. Performance on head-position identification task over successive administrations in percent correct. Each symbol represents a different subject.

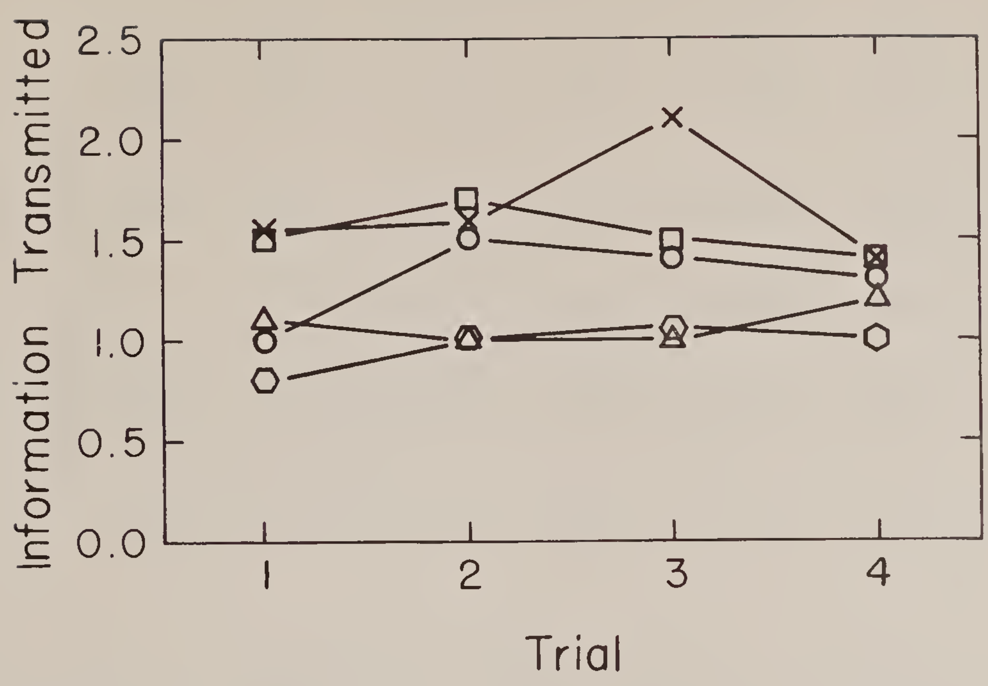

Figure IV-2. Performance on head-position identification task over successive administrations in information transmitted (bits/response). Each symbol represents the same subjects seen in Fig. IV-1.

Since this task will be used to distinguish among people, the most useful measure of performance is one in which the relation among subjects is maintained. The correlation (coefficient of concordance) among subjects over successive trials was .544 for percent correct and .875 for information transmitted. From this analysis we conclude that the most useful performance measure is information transmitted. Once the ability of a subject has been determined, he is more likely to maintain his relation to other subjects in information transmitted than in percent correct.

Homogeneity among the different head positions was determined by pooling the data from each subject over all trials (2000 responses). The stimulus-response confusion matrix from this analysis is seen in Figure IV-3. Each cell entry is the conditional probability of a response to each stimulus. This matrix shows that the precautions taken to prepare this test resulted in reasonable homogeneity among the test items.

The four trials were done under different criteria. The instructions to each subject for his first trial were, "If you are sure of your decision, say yes; if you are not sure of your decision, say no". On the following three trials, each subject was instructed to change his criterion to more strict or lax, depending on his criterion for the previous trial. The order of successive criteria was fortuitous among subjects.

	RESPONSE (received)				
STIMULUS (sent)	R90	R45	F-0	L45	L90
R90	.7700	.2025	.0125	.0100	.0050
R45	.0550	.7575	.1475	.0400	.0000
F-0	.0025	.1425	.7475	.1050	.0025
L45	.0025	.0350	.2550	6275	.0800
L90	.0050	.0050	.0300	.2175	.7425

Figure IV-3. Confusion matrix of the head-position identification task for all subjects pooled over trials.

The results for each subject under four criteria are shown in Figure IV-4. The ordinate is the probability of a correct conformation and the abscissa is the probability for an incorrect conformation. These results show (1) that a subject can vary his criterion from strict to lax, and (2) that changes in criteria describe a linear function. From a least squares solution to the points defining different criteria, we can predict the behavior of subjects on this task by the following relation:

$$P(Y|C) = .60\ P(Y|I) + .44$$

Before a test of this prediction is made, however, we shall consider the relation between performance and criterion. Both high and low performance measures fall above and below the line of best fit (Figure IV-5) indicating that there is no relation between performance and criterion. Specifically, there is no relation between the probability of a correct conformation and either the percent correct or information transmitted; and there is no relation between the probability of an incorrect conformation and either the percent correct or information transmitted. From these results we conclude that a subject's performance and his criterion are independent.

Experiment II: The purpose of this experiment was to test the prediction established in Experiment I. Three blind subjects with normal hearing were tested. One was tested four times, each under a different criterion. The remaining two were tested only once under the instructions given to the sighted subjects in Experiment I during their first trial.

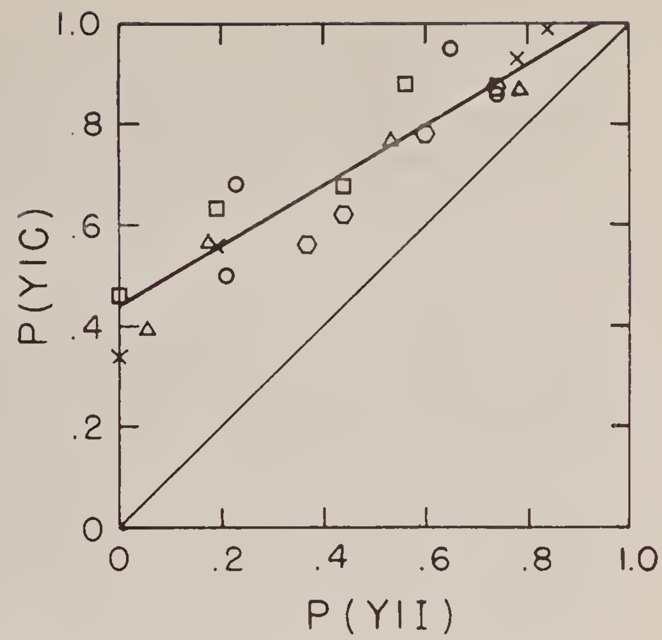

Figure IV-4. Performance of each of five sighted subjects on the head-position identification task under four different criteria.

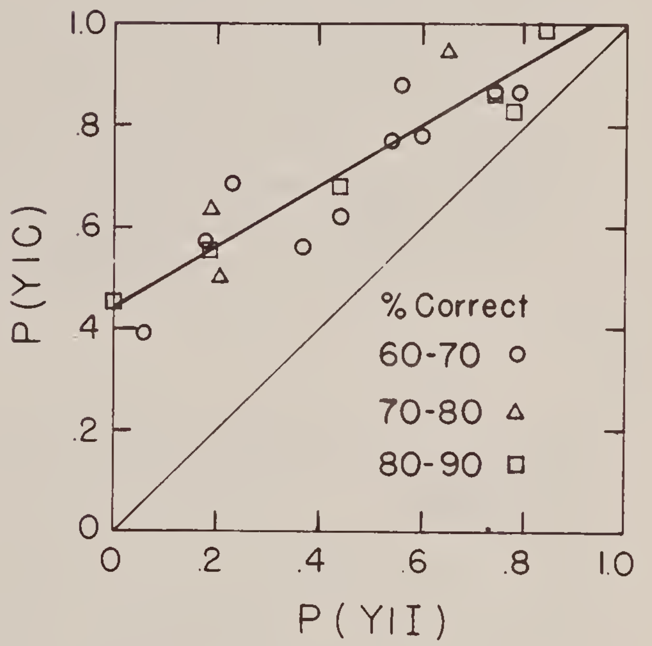

Figure IV-5. Relation between percent correct and predicted performance on head-position identification task.

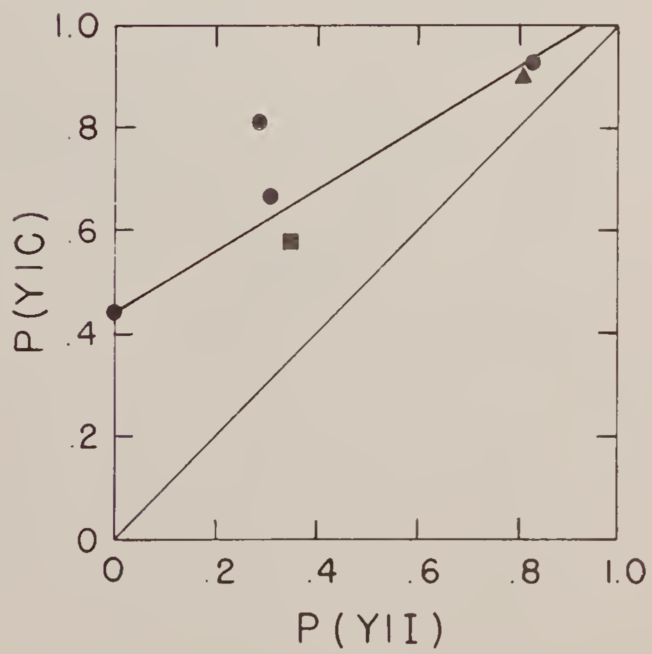

Figure IV-6. Performance of three blind subjects (one under four different criteria) on head-position identification task.

From the results shown in Figure IV-6 we see that the blind subjects fall close to the prediction established for sighted subjects in Experiment I. Consequently, the least-squares fit to the data of Experiment I predicts the criterion of both blind and sighted subjects on this task of head-position identification.

<u>Experiment III</u>: A preliminary examination of the two hypotheses tested by this experimental task can now be made because each subject was first tested under neutral instructions. As previously stated, each subject was told, "If you are sure of your decision, say yes; if you are not sure of your decision, say no." In addition we can compare the results of sighted and blind on both their performance and criterion.

Figure IV-7 shows the criterion of the blind (filled circles) and sighted (open circles) subjects. These relations show that the blind travelers, in general, were more lax than the sighted. The two blind subjects who were lax both used a cane while the blind subject who tended to be strict used a guide dog. Apparently the relation between criterion and position on the mobility scale was a reasonable hypothesis. More blind travelers are necessary, however, before an adequate test of the hypothesis that good travelers are lax on this task is possible.

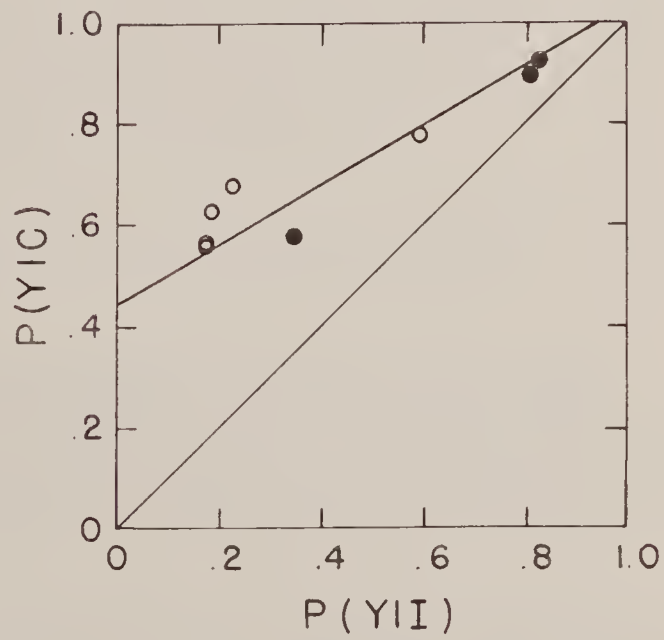

Figure IV-7. Criteria of sighted (open circles) and blind (filled circles) on head-position identification task during first administration.

The percent correct and information transmitted for each subject is shown in Table 1. These preliminary results show that the blind are probably no better able to identify head position than the sighted. These preliminary findings, however, may not be consistent with the results on a larger sample of cases.

Table 1: Performance of blind and sighted subjects on head position identification task.

	Subject	% correct	Information transmitted
Sighted	DW	65	1.031
	PM	79	1.555
	HW	66	1.112
	MS	60	0.769
	JC	84	1.623
Blind	EA	63	0.743
	WF	55	1.239
	JD	82	1.617

Conclusions: The results of the experiments on head-position identification show that performance (percent correct, information transmitted) and criterion (lax, strict) are independent.

Analysis of performance showed (1) the test items are homogeneous, (2) subjects do not change significantly over successive test administrations, and (3) the best measure of a subject's ability is information transmitted.

Analysis of criterion showed that different criteria for both blind and sighted describe a linear function, $P(Y|C) = .60\ P(Y|I) + .44$.

Preliminary study of the differences among the blind and sighted suggests there are no differences in performance, but probably differences in criterion. The results further suggest that the more mobile a blind person is, the more lax his criterion.

Continuation: Additional testing of a larger group of blind subjects will be done now that the parameters of this task are specified.

<u>Street-Crossing Decisions</u>.

Crossing a street is a task both blind and sighted accomplish when they walk more than one block. The blind, however, rely mainly on auditory information to decide when a street is safe to cross. The purpose of the following experiments is to evaluate street-crossing behavior among blind travelers.

Ease of deciding when a street can be crossed safely depends on the predictability of traffic to a great extent. A situation in which vehicles come from only one direction, for example, is less difficult than one in which vehicles come from any one of four directions. Similarly, a situation in which traffic is regulated (stop lights and signs) is less difficult than one in which there is no regulation.

Street crossing decisions were made in the following experiments on a single street (actually a highway) with vehicles going in both directions. There were no traffic controls.

<u>Experiment IV</u>: The first attempt to investigate street-crossing decision behavior among the blind was a free-response situation, comparable to that encountered in field conditions. One sighted and one blind judge stood by a highway and independently decided (raised their hands) (1) when they would cross, and (2) when they would no longer cross. The time between these two judgments we shall call the safe-crossing interval.

The times (to the nearest second) judged safe and not safe by the sighted observer defined the safe-crossing interval. There were 13 such intervals.

The same blind subject later judged the safe-crossing intervals from a recording. He listened (1) through earphones, (2) through loudspeakers, and again (3) through earphones. A second blind traveler and a sighted, experienced listener also judged the safe-crossing interval through earphones.

A safe-crossing in the field was usually judged later by the blind than by the sighted. Unsafe judgments, however, frequently occurred at the same time. The blind observer, therefore, had less safe-crossing intervals and when they did overlap with the sighted judgment, they were shorter. These results suggest that judgment of safe by the sighted is based on visual information and unsafe by auditory information.

The results, summarized in Table 2, show the effect of criterion changes and illustrate how such changes make these data difficult to interpret. As a subject becomes more strict, his percent correct judged crossings during a safe interval increases. Notice on trial (1) that subject J.D. had an 80% correct choice and an 8% incorrect choice. Under a more strict criterion (trial 4) he made no incorrect decisions.

Table 2. Percent agreement, disagreement, and correct choice responses of safe interval in street-crossing decisions. All results compared to sighted field judgments.

Comparison	Subject	Trial	Agreement	Dis-agreement	Correct Choice
Blind Field	JD	1	32	8	80
Blind Earphones	JD	2	48	8	86
Blind Loudspeaker	JD	3	72	16	82
Blind Earphones	JD	4	31	0	100
Blind Earphones	RW	1	64	32	67
Sighted Earphones	PC	1	40	24	62

An extremely crude estimate of criterion from these data is possible. The percent agreement with the sighted judge is similar to the probability of a correct choice; and the percent disagreement is similar to the probability of an incorrect choice. The data analyzed with the technique used in the head-position identification experiments, are summarized in Figure IV-8. These results may be interpreted to indicate that all subjects were operating under strict criteria.

These data are difficult to interpret, however, because the observation interval is not specified. A method for analyzing such data was presented by J. P. Egan at the meeting of the Acoustical Society of America, held in Philadelphia on 12 May 1961, in the session on psychological acoustics.*

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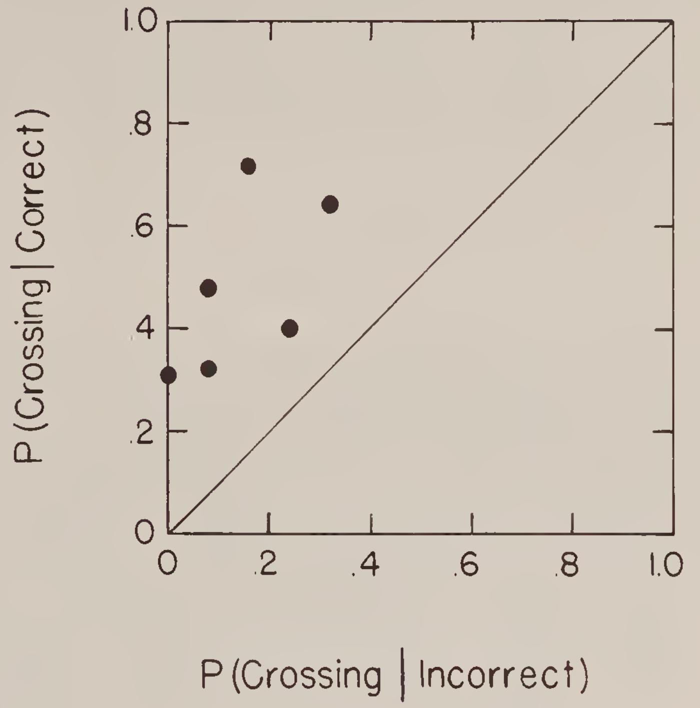
*James P. Egan. Method of Free Response in Signal Detection: A Simplified Technique. Paper presented to the Acoustical Society of America (R2) on May 12, 1961.

This technique requires that the experimenter obtain a greater number of responses than is reasonable to require of the individual blind subjects who will participate in this investigation. A more desirable test situation, for the purposes of this investigation, is one in which a subject is forced to make a yes-no decision to a specified stimulus.

Figure IV-8. Estimate of criteria used by the subjects during street-crossing decision. Observation intervals not specified.



<u>Experiment V</u>: The purpose of this experiment was to determine the feasibility of evaluating street-crossing decisions by a forced-choice technique. The time interval between vehicles was timed while three sighted subjects crossed the street independently. The minimum interval required for these sighted subjects to easily cross was 10 seconds. Crossings were made, however, by half walking and running in 5 seconds. These two intervals between vehicles defined safe and unsafe crossing periods.

A test was prepared in a manner similar to that used in the head position experiments with the dummy head facing the highway. It consisted of 50 safe and 50 unsafe intervals randomly ordered over the 100 items. Each item was 20 seconds long and was separated from the next by 5 seconds.

One blind subject took this test and a second listened. The responses were not analyzed because (1) the 20 second interval for each test item was too short for the subjects to adequately judge, (2) the test was too long, and (3) similarity among items was easily recognized. For these three reasons, this technique was not considered desirable as a procedure to evaluate street-crossing decision behavior among the blind.

Conclusion: The experiments to investigate street-crossing decisions among the blind show that a free-response technique must be used. The time required for adequate application of this approach, however, makes it impractical for use in this investigation.

Continuation: Because of the inherent difficulties in obtaining adequate data are insurmountable within the time limitations of this investigation, a complete analysis of street-crossing decision behavior among the blind will not be pursued further.

Primary Auditory Abilities.

A test of primary auditory abilities developed at the Naval Medical Research Laboratory*, will be administered to the blind subjects used in this investigation. It samples (1) pitch memory, (2) pure tone audiogram, (3) three loudness factors, (4) pitch modulation, and (5) some complex discrimination factors. The purpose of administering such a test to the blind is to determine if they are different from the sighted. If differences in primary auditory abilities are found, we can infer that the blind either do or do not possess some unique auditory skills.

Summary.

The three experiments designed to test the hypothesis that mobility differences among blind travelers is related to their ability to use auditory information are in different stages of completion.

The head-position identification task is complete. We know that (1) a subject's criterion and performance are independent, (2) the test items are homogeneous, (3) there is no improvement in performance over successive administrations, and (4) the best measure of a subject's performance is information transmitted.

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*A preliminary report on a bettery of primary auditory abilities may be found in a report by J. D. Harris, "A Search Toward the Primary Auditory Abilities", Memorandum Report No. 57-4, USN Medical Research Laboratory, Groton, Conn., 25 April 1957.

The street-crossing decision task was evaluated under two different procedures. A forced-choice technique was not found feasible. A free-response technique, although it did yield some useful data, also was not found feasible because of the necessity for obtaining a large number of responses for each subject which would make the task too long for the naive blind subject. The street-crossing decision task, therefore, was discontinued as an approach to distinguish among blind travelers.

The primary auditory abilities battery at the Naval Medical Research Laboratory has not yet been attempted on any blind subject.

V AUDITORY TRAINING FOR THE BLIND

H. N. Wright and J. K. Dupress

One definition of auditory training is the use of techniques to improve an individual's ability to identify sounds not previously recognized. Although such techniques have long been used with the hearing impaired, they have not been systematically applied to the blind to improve their mobility. The reason for this development is perhaps because the purpose of such training is different for each of these groups of individuals.

The purpose of auditory training for the hearing impaired is to improve the use of residual hearing so that most of what is said is identified. The purpose of auditory training for the blind, however, is to improve orientation by obstacle detection and identification. This difference in purpose requires a different analytical approach to the problem of training, even though some of the techniques are common to both of these groups of individuals.

In all auditory training techniques, the listener proceeds from easy to more difficult sound discriminations. When a given degree of competency in discrimination is accomplished, the ability to identify sounds not previously recognized as different from each other is improved. The limit of an individual's ability to identify different sounds is determined by the degree to which he discriminates among different kinds of sounds. An analysis of the requirements for a complete auditory training program for the blind is developed below, after a discussion of the general techniques already found useful for the hearing impaired.

General Techniques.

Easy to more difficult sound discriminations are obtained by gross to fine differences among sounds. Although the ease of discriminating among most sounds depends upon hearing status, the way in which gross to fine differences are produced does not. The complexity of sounds is varied by changing (1) spectrum and (2) temporal pattern. The third variation in complexity is the transitional properties produced by a combination of spectrum changes and temporal pattern.

A simple spectrum contains a single frequency at some intensity. Such a spectrum has a definite pitch and loudness. More complex spectra are produced by adding more frequencies and have, in addition to loudness, a definite quality. Different temporal patterns are produced by varying the duration of successive sounds and the silent interval between each.

The spectrum changes accompanying such variations provide transitional information.

Discrimination among sounds that differ in all of the above three aspects is easy. More difficult discriminations are obtained by reducing the number and degree of these differences.

Principles for the Blind.

The techniques of auditory training for the blind are identical to those used with the hearing impaired for the detection and identification of those obstacles that act as a sound source. Since the purpose of the training is different, however, two additional considerations are necessary: (1) sound shadow and (2) sound echo.

A framework, or theoretical model, useful for analyzing those parameters necessary for a systematic approach to a method of auditory training for the blind has, therefore, three levels of complexity. These levels are shown as separate cases in Figure V-1.

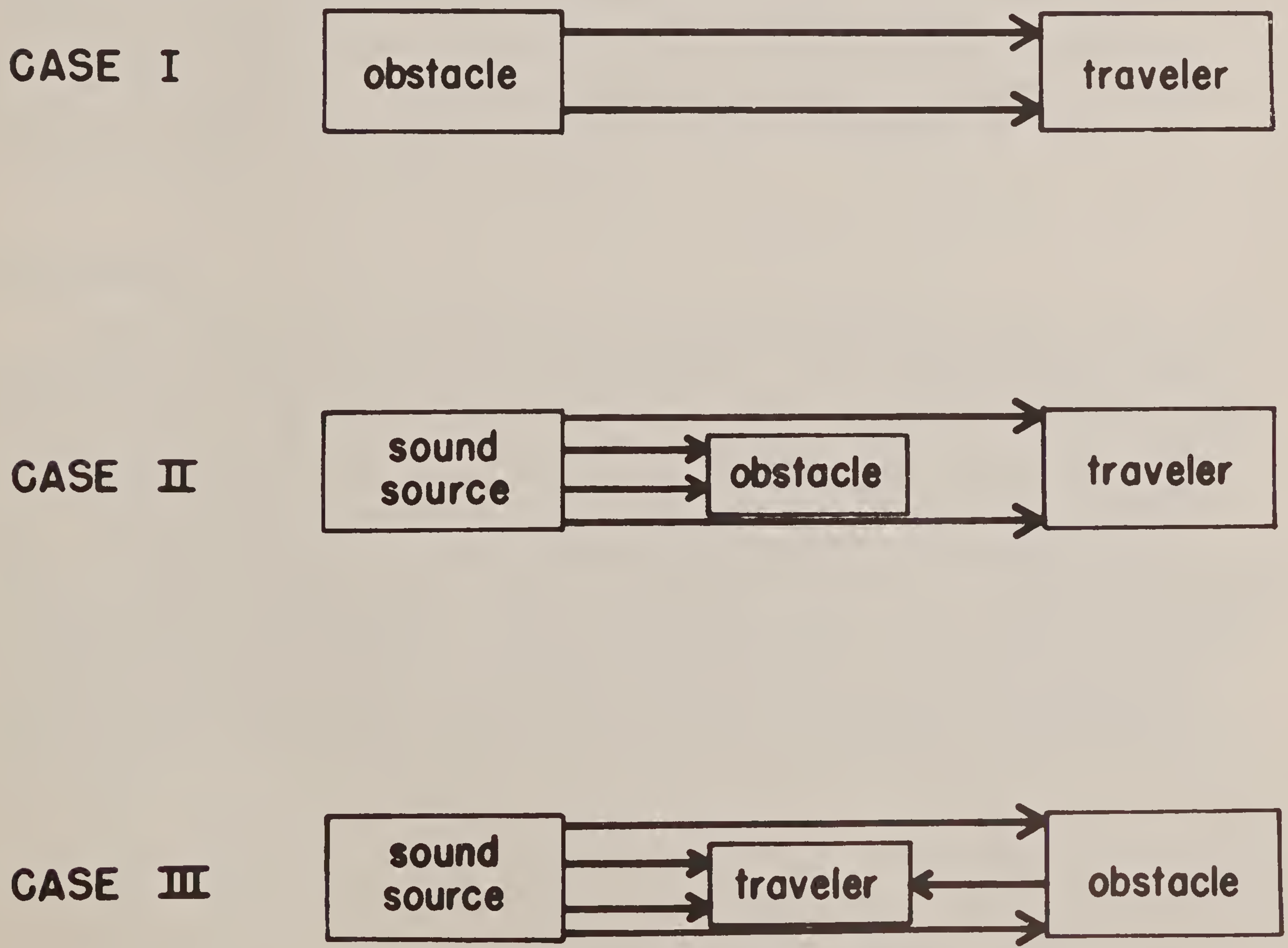

Figure V-1. Theoretical model for analyzing the parameters necessary for a systematic approach to a method of auditory training for the blind.

Case I is the identification of an obstacle by the sound it produces. The most important obstacles that act as a sound source are automobiles, trucks, and buses. Other obstacles that are easily identified by the sound they produce are people (by their footfalls and talking) and perambulators. The detection of obstacles in this case depends upon 1) the spectrum of the sound source and 2) the distance of the traveler from the obstacle.

Case II is the detection of an obstacle by the sound shadow it produces. The quality of a sound changes when an obstacle is placed between the observer and the sound source because the obstacle blocks the higher frequencies much in the same way as it blocks light. Two examples of such obstacles are telephone poles and parked automobiles. The detection of obstacles in this case depends upon: 1) the spectrum of the sound source, 2) the size of the obstacle, 3) the distance of the traveler from the obstacle, and 4) the distance of the obstacle from the sound source.

Case III is the detection of an obstacle by the sound echo it produces. The best example of such an obstacle is a building. Changes in the building line, say a store entrance, can be detected by changes in the sound echo. The detection of obstacles in this case depend upon: 1) the spectrum of the sound source, 2) the size of the obstacle, 3) the composition of the obstacle, 4) the distance of the traveler from the obstacle, and 5) the distance of the obstacle from the sound source.

Conclusion.

From the above framework, we can easily see why auditory training for the blind is not simple. All three cases considered in the model can, and most often do, occur simultaneously under different spatial relations. Since blind travelers frequently make their auditory judgments while moving, they constantly change the varying sounds that reach their ears. This double change (changing sounds, changing position), coupled with the three separate types of considerations for analysis, increases the difficulty for the blind traveler of obtaining consistent auditory information. An auditory training program for the blind to be most effective should include all the above aspects before it can be considered complete.

VI TRAINING MATERIAL PREPARATION

J. F. Curtis

The first step in preparing auditory training materials for the blind is to verify that binaural presentation provides more directional information than monaural presentation. To achieve this, the head-position identification task discussed previously was given to five subjects, monaurally. These subjects had also received the test binaurally. The procedure was identical to that used previously, except on the first administration the subjects listened with only the right earphone; while on the second administration, they listened with only the left earphone. The mean difference between binaural and monaural performance for percent correct was 39%.

We conclude from these results that auditory training materials for the blind must be binaural in those instances where localization is important. A further conclusion, mentioned by others in the literature, is that although two ears are more efficient than one, both are not necessary to obtain some localization information.

Figure VI-1. Simplified diagram of mobility area.

Figure VI-1 is a simplified diagram of the mobility area chosen for preparation of both the auditory and model training materials. The darkened portion represents the travel course (sidewalk). The area combines most of the circumstances encountered by the blind traveler. The width of the sidewalk changes as does the position of the buildings in relation to the sidewalk as one walks down the area. It will be noted from the diagram that in the center of the course one encounters a deeply recessed building. Immediately following this is an alley and then the buildings once again are beside the traveler. Throughout the mobility area, the changes in the building lines provide a variety of acoustic modifications of the sound of passing traffic.

Auditory Training: Two types of binaural recordings were made from the dummy head discussed previously: (1) stationary and (2) moving. The purpose of the stationary recordings was to provide isolated examples of the sounds received by a traveler in different locations within the mobility area. The purpose of the recordings made with the head moving through the travel area was to simulate the auditory information received by blind travelers.

These recordings were made at a time when there were no pedestrians and sufficient traffic flow so that there was adequate, but not deleterious, information in the recordings. Judgment of information adequacy was made by a blind expert traveler from the American Foundation for the Blind, the consultant to this project.* From these judgments we concluded that the ambient sound level from the traffic could not only be insufficient, but also so great that some discriminations were not possible. The basis for adequacy of auditory information, although apparently related to the amount of traffic, was not pursued. We know only that the final recordings are adequate for auditory training purposes.

The stationary recordings were made with one ear of the head facing the street in three different kinds of location: (1) next to a building, (2) at the corner of a building, and (3) in the open area containing the deeply recessed building (see Figure VI-1). While listening to the prepared materials, we learned, after a series of approximations, that our early recording attempts were not successful because the head was too far away from the wall. The final recordings for training and test purposes were made with the head about eight inches from the wall.

One principle, useful for training the blind, was abstracted from these recordings by listening. This was the difference between the reflected sound to one ear and the direct sound to the other in each of the three positions. The sound from a passing car obtained with the head next to a building (the reflecting surface was plate glass) successively appeared to (a) increase its loudness and volume, (b) drop to a null, (c) increase in loudness and volume again before disappearing altogether. When the head was at the corner of a brick building, however, two nulls were heard.

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*Mr. John K. Dupress, Director of Technological Research, American Foundation for the Blind, 15 West 16th Street, New York, N. Y.

Finally, the sounds reflected from the distant building in the open area arrived observably later than the direct sounds. The time lag here was so great that the periodic impulse sounds from some foreign cars reflected from the building to the ear away from the street were heard between those that went to the ear toward the street directly.

The moving recordings are an extension of those made with the head stationary. Given the information on direct and reflected sound obtained from the stationary recordings, it was possible to appreciate when the head moved into and out of the open area. Although the direction of movement on the travel course was easily detected by listening, some of the more subtle distinctions observed in the stationary recordings were identified only by repeated listening. For training purposes, however, these moving recordings as well as the stationary ones, were edited and commentary inserted.

The resultant auditory training tape consists of two major sections: (1) a brief history of commercial sound recording from early acoustic to stereophonic recordings, and (2) the travel training material.

The first section, recounting the history of recording, is included to familiarize the subject with listening under headphones in general and listening to binaural recordings in particular. The section includes musical selections of a popular sort and some sound effects such as railroad trains and airplanes. The material was taken from the Ampex Stereophonic Demonstration Tape. The segment is 8 minutes in length and the subject hears it only once.

The second portion of the training tape consists of both moving and stationary recordings made in the mobility area. The first selections are taken from the stationary recordings made in the three locations discussed previously. The important auditory cues are first discussed by the narrator just prior to their occurrence on the tape. A two or three minute segment of traffic sounds interspersed with narration is presented, then repeated without the narration so that the listener may attend to the sounds with interruption. After six segments of this type, the moving recordings are introduced. Again these are two or three minute segments, but include a complete trip from one end of the course to the other. These three segments do not include any narration, with the exception of some introductory remarks prior to the section.

Model Training: A training technique sometimes used to improve mobility within a defined area is the scale model. The blind traveler familiarizes himself with an area in which he is to travel by feeling his way around a model. Such orientation presumably facilitates his mobility, at least within the defined area. Two questions arise, however, in the preparation of a model: (1) its size and (2) the amount of detail.

A large scale model (4' x 8') of the mobility area described above was prepared. The adequacy of this model was judged by two blind travelers, one the consultant to this project and the other a representative of the Veterans Administration.* The independent opinion of these consultants was that this model was too large and detailed. Those details considered necessary, viz. loss of curb line, telephone poles, and shrubbery were included in a smaller model (2' x 4½') subsequently constructed. This small model is the one that will be used by the blind travelers in this investigation.

Experimental Design.

Procedure: The experimental paradigm designed to test the hypothesis that auditory training facilitates mobility requires three groups of blind subjects, each receiving a different kind of training. One group will be given only auditory training while a second group will train only with the model. The third group will receive both types of training, auditory and model. Some of the subjects will walk through the mobility area, then receive training, repeat their trip through the mobility area and walk through another area with which they are not familiar. (This latter area is called the generalization area.) Another group will receive the training first, then make two trips through the mobility area, and one through the generalization area.

Performance Measures: Two measures of performance have been chosen: (1) the time taken to complete each portion of the course, and (2) an assessment of the subject's path down the sidewalk.** The first is determined with a stop watch.

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*Russell Williams, Chief, Blind Rehabilitation, Department of Medicine and Surgery, Veterans Administration, Washington 25, D. C.

**Originally we had planned to take motion pictures of the subject as he walked the course, but the subject is so often obscured by other pedestrians and obstacles that the technique has been abandoned.

The second by means of ten points along the course chosen as check points--selected on the basis of changes in the acoustic environment. The width of the sidewalk is marked off every six inches at these check points. The point which the subject crosses as he passes down the walk gives an estimate of his position within the boundaries of the sidewalk. The average deviation or some other measure of dispersion will provide an estimate of variability of travel through the area.

A group of sighted, blindfolded subjects will be used first, following the same paradigm to be applied to the blind travelers. This will allow us to perfect the performance measuring techniques and develop the most efficient schedule for the blind travelers.

VII SUMMARY

J. K. Dupress

Near the mid-point of this research project (20 months), a variety of tests and training materials have been completed, and in some instances, validated.

The mobility competency scale has been validated using both sighted and non-sighted subjects. The scale will be given to blind subjects to determine their level of mobility competency.

The interview material and supplementary tests consist of the following:

1) General personal background
2) Questions concerning previous travel training
3) The mobility competency scale referred to above
4) Verbal Wechsler (Intelligence)
5) Emotional factors inventory

The head-turning or localization test will be given to both good and poor travelers as well as the home-bound.

The primary auditory abilities test was completed and testing of subjects begun. The test consists of the following parts:

1) Pitch memory
2) Pure tone audiogram
3-5) Three loudness factors
6) Pitch modulation
7) Some complex discrimination factors

Twenty-eight blindfolded sighted subjects have been used in the mobility area to test the paradigm design which measures the usefulness of auditory training materials and tactile presentation.

The first training tape was completed. It consists of the following parts:

1) An introduction to binaural presentation
2) Stationary and moving binaural recordings with commentary

The validation of this training tape will be done both at Shilling and rehabilitation centers.

During the next six months, part of the testing of blinded subjects will be done in the New York and Boston areas in order that enough time be made available for a more thorough evaluation of the actual mobility aspects of performance when these subjects visit the Shilling Center in Groton, Connecticut.

It is expected that twenty-five or more totally blind subjects will be able to complete the interview and all other testing within six months. Each subject will receive all the material listed in this summary.

VIII APPENDICES

Directions for Administration of the History Form.

If the response to any question is not clear, the examiner should ask the subject to explain his answer more fully.

Items not covered on this sheet are assumed to be self-explanatory.

4. The reference sought is the name of the agency through which the subject's name was acquired.

11. Line one indicates the most recent past address. Line two indicates the city before that, etc.

12b. Omit this question if the subject's answer to 12a. is no.

13. If the subject does not recall his V.A. Claim No., ask him if he has any papers with him that might give us this information.

14. B/S indicates blind or sighted. If the subject graduated from college, ask him what degree he received. Also ask him if he did any graduate work. Include this under comments.

15a. This question refers to <u>any</u> travel training program in which the subject may have participated. The formality or duration of the program is not important. If answer is no, proceed to Question 16.

15b. If the subject is vague in his report on types of training, help him be more specific by suggesting possible types, such as auditory, cane, tactual, or dog.

16c. Refers to the onset of blindness.

16e. This question refers to the most recent examining physician.

17a. See discussion of the mobility scale.

1. For the purpose of this question, the place in which a subject lives is defined by the area over which he has control. If a subject lives in his own

home or has a private entrance in a multiple dwelling, he goes away from the place in which he lives when he goes beyond the yard. On the other hand, if a subject lives in an apartment house or does not have a private entrance, he goes away from the place in which he lives when he goes out of his specific living quarters. If his answer to this question is yes, proceed to 2; if the answer is no, proceed to 17b.

2. If the subject's answer indicates that he has ever gone away alone from the place in which he lives, proceed to 3; if his answer indicates that he has never gone away alone, proceed to 4.

3. Record any type of assistance used by the subject. If he uses more than one type, record the type which indicates the greatest degree of mobility competency as listed in 17b.

4. Ask this question only if the answer to (1) is yes. If his answer to this question (4) is yes, proceed to 5; if no, proceed to 17b.

5. If the subject says that he went with someone else, proceed to 17b; if he says he went alone, proceed to 6.

17b. Check the type of assistance the subject uses in both familiar and unfamiliar environments.

17c. Record the subject's position on the mobility scale in which 1 indicates the greatest degree of mobility competency, and 15 which indicates the least degree of mobility competency.

1. Name (Last, First, Middle)

2. Examiner

3. Date

4. Referred by

5. Sex

6. Maiden Name if Married

7. Date of Birth

8. Place of Birth (City, State)

9. Present Address (Street, City, State)

10. Phone No

11. Past Addresses (Street, City, State)

1 ____

2. ____

3. ____

4. ____

5. ____

12a. Were you ever in the Armed Forces

12b. Branch of Service

Army ____ Navy ____ Air Force ____ Marines ____ Coast Guard ____ Other ____

13.

Rank ____ Serial No. ____ V.A. Claim No. ____

14. EDUCATION	B/S	NAME	GRADE COMPLETED	LOCATION
Grammar				
High School				
College				
Technical Training				

Comments

TRAVEL TRAINING

15a. Did you ever have any travel training

15b. What types of training did you have

15c. Do you feel that the training has helped you

Comments

16. BLINDNESS

a. Age at which totally blind

b. Cause of blindness

c. Sudden Gradual

d. Treatment

e. Examining Physician Location

Comments

17. Determination of Mobility Competency

a. Assistance

1. Do you ever go away from the place in which you live

2. If yes, do you ever go alone or do you always go with somebody else

3. When you go alone do you use anything to help you such as a cane, dog, etc.

4. If (1) is yes, during the last year did you go anywhere that you have never been before

5. If (4) is yes, did you go alone or with somebody else

6. When you went alone, did you use anything to help you such as a cane, dog, etc

17. (Cont'd)

b. Subject's Position on Mobility Scale

	Familiar	Unfamiliar
none	______	______
cane	______	______
dog	______	______
companion	______	______

C. Numerical Position on Mobility Scale ______

Comments

18.
I. Q.

19 EFI SCORES

1. Sensitivity ______
2. Somatic Symptoms ______
3. Social Competency ______
4. Paranoid Tendencies ______
5. Inadequacy ______
6. Depression ______
7. Attitudes Toward Blindness ______
8. Validation ______

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USE OF AUDITORY CUES BY THE
BLIND FOR TRAVEL.
(1961)